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Assistant Commissioner for Patents
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CERTIFICATE OF MAILING (37 C.F.R. § 1.8(a))

Sir:

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Der Präsident des Europäischen Patentamts;
Im Auftrag

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Method for controlling the starting of an internal combustion engine

The present invention relates to a method for controlling the starting of an internal combustion engine comprising an exhaust aftertreatment device that requires a minimal threshold temperature for proper operation. Moreover, the invention relates to a system comprising an internal combustion engine, an exhaust gas aftertreatment device, an electrical generator, and an engine controller.

During the last few years regulations for the protection of the environment have become increasingly stringent. This makes it for internal combustion engines more and more difficult to meet legal requirements, though exhaust aftertreatment devices like three-way catalysts, conventional oxidising catalysts and particulate filters are standard today. Especially diesel engines are problematic due to high emissions of carbon monoxide CO and hydrocarbons HC.

It is an object of the present invention to provide an improved method for the control of an internal combustion engine with an aftertreatment device, the method producing less overall emissions during operation.

According to a first aspect of the invention, a method for controlling the starting of an internal combustion engine is provided, the engine comprising an exhaust aftertreatment device that requires a minimal threshold temperature for proper

operation. During a certain period of time after engine start the following steps are performed:

a) increasing the electrical load of an electrical generator that is driven by the engine; and

b) throttling the air intake to reduce the intake manifold pressure to a target pressure.

The proposed method achieves a considerable reduction in emissions of the internal combustion engine by focusing on the starting period of the engine. During warm-up of the engine, the aftertreatment device is still cold and therefore not in its optimal working range or even not operative at all. The exhaust gas is therefore released into the atmosphere essentially untreated. This leads to high emissions during engine start, which represent a considerable fraction of the total emissions of the internal combustion engine.

The method according to the present invention addresses these problems and provides a faster engine warm-up by performing steps a) and b). During step a), additional power is consumed by the loads that are coupled to the generator. This leads to a higher load for the engine, too, which in turn results in a faster warming of the exhaust gases. Thus, the period of time during which the aftertreatment device is not operative is reduced. Step b) contributes further to this effect because throttling air flow through the engine means that less mass has to be heated with a given amount of heat, yielding higher temperatures. Moreover, efficiency of the engine is reduced and pumping losses are increased, leading to a higher heat production.

The electrical loads that are coupled to the generator in step a) preferably comprise electrical consumers that are present in a vehicle anyway, e.g. at least one glow plug of the engine or an electrical heater of the cabin or the windshield. The advantage of said consumers is that their short-term operation as additional load will not be noticed by the driver.

According to another aspect of the invention, exhaust gas recirculation is reduced or stopped during step b). Due to the reduction of the intake manifold pressure, the pressure difference between intake manifold and exhaust manifold increases, which may lead to an excessive exhaust gas recirculation. This excessive recirculation is prevented if the exhaust gas recirculation is reduced or stopped, e.g. by closing respective valves.

If a turbine with variable geometry is present in the engine, it may be operated open-loop only during step b). This prevents a turbocharger overspeed which might result from the throttling of the intake and the attempt to stabilise a certain intake manifold pressure.

Preferably it is first tried to reach the desired exhaust temperature by step a) alone. If this does not succeed, however, step b) will be carried out additionally. The decision to include step b) or not will preferably be taken in dependence on the exhaust temperature behind the aftertreatment device. Thus, step b) will only be carried out if exhaust gas temperature behind the aftertreatment device is below a given threshold temperature.

The goal of the method according to the present invention is to reach as fast as possible a temperature of the exhaust gas that is above the threshold temperature for proper operation of the aftertreatment device. Therefore, steps a) and b) are preferably stopped if exhaust gas temperature has reached this threshold, thus limiting the time spent within the exceptional engine mode of steps a) and b).

In order to avoid undesirable implications of steps a) and b), these steps are preferably only carried out if the temperature of the engine at start is within a certain temperature interval, i.e. not too high and not too low.

The invention also comprises a system with an internal combustion engine, an exhaust gas aftertreatment device, an electrical generator, and an engine controller. In this system, the controller is adapted to execute one of the methods described above. Such a system has the advantage to warm up quickly, thus minimising the time of essentially unfiltered emissions due to an aftertreatment device that has not reached its operating temperature yet.

Preferably, the combustion engine comprises a diesel engine, and/or the aftertreatment device comprises an oxidising catalyst. Presently, diesel engines emit most of the CO and HC emissions during engine and catalyst warm-up. The oxidising catalyst does not convert the CO and HC leaving the engine until it has reached a temperature of about 200°C. Therefore, the advantages of the present invention are most prominent in conjunction with such a diesel engine and/or an oxidising catalyst. Here, a considerable reduction in total emissions over several drive cycles can be achieved.

The invention will now be described by way of example in connection with the accompanying drawing.

The only figure shows a flowchart of a method to control the starting of an internal combustion engine according to the principles of the present invention.

The goal of the inventive method is to increase the exhaust gas temperature after engine start quickly to improve catalyst performance. The method will be described with reference to a preferred implementation that comprises a diesel engine equipped with an exhaust gas recirculation (EGR) system, an intake air throttle, an oxidising catalyst, and a temperature sensor downstream of that catalyst. Moreover, the engine comprises an engine control unit (ECU) which is programmed with the necessary software in order to execute the inventive algorithm. The algorithm is executed as part of the overall engine control strategy at a fixed sampling rate, e.g. once every 16 ms.

After start of that algorithm in block 10, the ECU initialises a timer t_start in block 11.

If the engine coolant temperature ECT is not within a range [ECT_min, ECT_max] that can be calibrated, the algorithm is terminated in block 12 in order to minimise impact on drivability and performance.

If the engine coolant temperature ECT is within said range, the algorithm checks in block 13 the catalyst outlet temperature T_exh. If T_exh is below a first predetermined threshold T_exh_min_1, for example 200°C, electrical loads are switched on in block 14 to put a higher load on the engine and thus

increase engine out exhaust gas temperature. Preferably only those loads are switched on that are not noticeable by the driver, such as windshield heater or glow plugs.

Once the exhaust gas temperature exceeds the first threshold T_exh_min_1, the electrical loads are switched back to their default or driver selected values.

Next, the algorithm checks in block 15 whether the catalyst temperature T_exh is below a second calibratible threshold T_exh_min_2, for example 150°C. If so, the additional electrical loads will not raise the exhaust gas temperature sufficiently, and the intake throttling feature is activated in block 16. Basically, the intake throttle is used to lower the intake manifold pressure (MAP) to a target pressure, MAP_ref, which is a function of speed and load. During this throttling, the EGR valve is closed, and the variable geometry turbine (VGT) is operated in open loop only.

The algorithm is terminated in block 17 or 18 after a calibratible period of time t_max because the algorithm may temporarily lead to higher feed gas emissions and therefore its operation should be limited to a fixed duration.

In an alternative implementation without exhaust gas temperature sensor, the checks on T_exh_min_1 and T_exh_min_2 of blocks 13 and 15 are not performed, and the algorithm is executed until the timer t_start has reached the maximum value t_max.

Claims

1. A method for controlling the starting of an internal combustion engine comprising an exhaust aftertreatment device that requires a minimal threshold temperature for proper operation, wherein during a certain time period after engine start the following steps are performed:

   a) increasing the electrical load of an electrical generator that is driven by the engine;

   b) throttling the air intake to reduce the intake manifold pressure to a target pressure.

2. The method according to claim 1, wherein the electrical load of the generator comprises at least one glow plug of the engine and/or an electrical heater.

3. The method according to claim 1 or 2, wherein exhaust gas recirculation is reduced or stopped during step b).

4. The method according to one of the claims 1 to 3, wherein a turbine with variable geometry is operated open-loop during step b).

5. The method according to one of the claims 1 to 4, wherein step b) is only carried out if exhaust gas tem-

perature behind the aftertreatment device is below given threshold temperature.

6. The method according to one of the claims 1 to wherein steps a) and b) are stopped if exhaust gas t perature behind the aftertreatment device is above s threshold temperature for proper operation of the aft treatment device.

7. The method according to one of the claims 1 to wherein steps a) and b) are only carried out if the t perature of the engine is within a certain temperat interval.

8. A system comprising an internal combustion engine, exhaust gas aftertreatment device, an electrical gene tor, and an engine controller, the controller be adapted to execute a method according to one of claims 1 to 7.

9. The system according to claim 8, wherein the inter combustion engine comprises a diesel engine.

10. The system according to claim 8 or 9, wherein the aft treatment device comprises an oxidising catalyst.

perature behind the aftertreatment device is below a given threshold temperature.

6. The method according to one of the claims 1 to 5, wherein steps a) and b) are stopped if exhaust gas temperature behind the aftertreatment device is above said threshold temperature for proper operation of the aftertreatment device.

7. The method according to one of the claims 1 to 6, wherein steps a) and b) are only carried out if the temperature of the engine is within a certain temperature interval.

8. A system comprising an internal combustion engine, an exhaust gas aftertreatment device, an electrical generator, and an engine controller, the controller being adapted to execute a method according to one of the claims 1 to 7.

9. The system according to claim 8, wherein the internal combustion engine comprises a diesel engine.

10. The system according to claim 8 or 9, wherein the aftertreatment device comprises an oxidising catalyst.

Abstract

Method for controlling the starting of an internal combustion engine

The invention relates to the starting of an internal combustion engine comprising an exhaust aftertreatment device that requires a minimal threshold temperature for proper operation. Within a certain period of time after engine start, first the load of an electrical generator driven by the engine is increased, and next the air intake is throttled to reduce the intake manifold pressure to a target pressure. Both measures provide a faster engine and catalyst warm-up and thus reduced emissions. This is especially true for a diesel engine in connection with an oxidising catalyst.